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Author: Erika J. Bagley, Ryan J. Kelly, Joseph A. Buckhalt, Mona El-Sheikh

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What Keeps Low SES Children from Sleeping Well:  
The Role of Pre-sleep Worries and Sleep Environment

Erika J. Bagley<sup>1</sup>

Ryan J. Kelly<sup>2</sup>

Joseph A. Buckhalt<sup>3</sup>

Mona El-Sheikh<sup>3</sup>

Corresponding Author: Erika J. Bagley  
Muhlenberg College  
Allentown, PA 18104  
[EBagley@muhlenberg.edu](mailto:EBagley@muhlenberg.edu)

<sup>1</sup>Muhlenberg College, Allentown, PA 18104 [EBagley@muhlenberg.edu](mailto:EBagley@muhlenberg.edu)

<sup>2</sup>University of New Mexico, Albuquerque, NM 87131 [ryankelly@unm.edu](mailto:ryankelly@unm.edu)

<sup>3</sup> Auburn University, Auburn, AL 36849 [buckhja@auburn.edu](mailto:buckhja@auburn.edu)

## Highlights

- Low SES children tend to have shorter sleep duration and more subjectively reported sleep problems.
- Reasons for this association are unclear.
- Pre-sleep worries were found to account for some portion of the association.
- Some conditions of the physical sleep environment were also found to be intervening variables in the association.

## Abstract

**Objectives:** Children in families of low socioeconomic status (SES) have been found to have poor sleep, yet reasons for this finding are unclear. Two possible mediators, pre-sleep worries and home environment conditions were investigated as indirect pathways between SES and children's sleep.

**Participants/Methods:** Participants were 271 children (M age = 11.33 yrs; SD = 7.74 mo) from families varying in SES as indexed by income-to-needs ratio. Sleep was assessed with actigraphy (sleep minutes, night waking duration, variability in sleep schedule) and child self-reported sleep/wake problems (e.g., oversleeping, trouble falling asleep) and sleepiness (e.g., sleeping in class, falling asleep while doing homework). Pre-sleep worries and home environment conditions were assessed with questionnaires.

**Results:** Lower SES was associated with more subjective sleep/wake problems and daytime sleepiness, and increased exposure to disruptive sleep conditions and greater pre-sleep worries were mediators of these associations. In addition, environmental conditions served as an intervening variable linking SES to variability in actigraphy-derived sleep schedule, and similarly,

pre-sleep worry was an intervening variable linking SES to actigraphy-based night waking duration. Across sleep parameters, the model explained 5% to 29% of variance.

Conclusions: Sleep environment and psychological factors are associated with socioeconomic disparities, which affect children's sleep.

Keywords: children, sleep, environment, poverty, worry

## Introduction

Sleep is increasingly being linked to multiple aspects of health and well-being in youth (Shochat, Cohen-Zion, & Tzischinsky, 2014). Experimental and observational studies have shown that sleep is critical to maintaining metabolic, endocrine, and immune functioning (AlDabal & BaHammam, 2011) and is related to health-related behaviors such as decreased physical activity, increased risk for substance use, and suicidal ideation (McKnight-Eily et al., 2011). Other research suggests that daytime sleepiness is related to behavior problems and mood (Fallone, Owens, & Deane, 2002), to lower levels of self-reported general health (Moore et al., 2009), and to increased risk for unintentional injury (Dahl, 2008).

Given the important role of sleep for overall health, it has been proposed that differences in various sleep parameters along socioeconomic lines may explain, at least in part, health disparities for a number of diseases (Hale, Peppard, & Young, 2007; Moore, Adler, Williams, & Jackson, 2002). This proposed link is underscored by research documenting socioeconomic disparities in sleep beginning in childhood. Studies on associations between family level economic disadvantage and sleep have shown that lower SES is associated with shorter sleep duration when assessed objectively using actigraphy (El-Sheikh et al., 2013; Marco, Wolfson, Sparling, & Azuaje, 2012; Moore, et al. 2011) and through self- and parent-report methods

(Adam, Snell, & Pendry, 2007; Fredriksen, Rhodes, Reddy, & Way, 2004). In addition to sleep duration, self-reported subjective sleep problems (e.g., trouble falling asleep, maintaining sleep, oversleeping) may be associated with family SES. Findings from the National Sleep Foundation's 2006 survey showed that adolescents with family income in the lowest bracket (< \$50,000) were more likely to report difficulty falling asleep and staying asleep as compared to those in the highest bracket (> \$100,000) (National Sleep Foundation, 2006). Related research has found that during late-childhood, lower income-to-needs ratio was associated with greater self-reported sleep/wake problems (El-Sheikh, et al. 2013).

*Possible Mediators linking Socioeconomic Status and Sleep*

The reasons *why* youth from lower socioeconomic backgrounds are at greater risk for shorter and worse quality sleep have not been well studied, and there is a need to identify mechanisms linking lower SES to poorer sleep (Knutson, 2013). The physical sleep environment is considered an important domain of "sleep hygiene" (LeBourgeois, Giannotti, Cortesi, Wolfson, & Harsh, 2005). The National Sleep Foundation's sleep hygiene recommendations include keeping the bedroom "comfortable, free from light and noise" and these recommendations are supported by research showing links between the sleep environment and sleep problems. A study of families in China, for example, found noisy home conditions to double the risk of children experiencing more than three symptoms of insomnia (Zhang et al., 2009). Fewer economic resources may make it more challenging for families to maintain sleep environments for their children that are quiet, dark, and kept at a comfortable temperature, however. Smaller domiciles, for example, make it more likely that young children will share a bedroom with siblings and tighter living conditions are associated with greater difficulty falling asleep (Milan, Snow, & Belay, 2007). Research has also found that children from lower income homes are three to four times more likely than those from middle and upper income brackets to have a television in their bedroom (Tandon et al., 2012). In a review of the literature, Cain and Gradisar (2010) found consistent evidence that the presence of a television

in the bedroom is related to shorter total sleep and higher levels of sleep disturbance. Therefore, it is possible that the sleep environment may be an important consideration when examining links between SES and sleep. Indeed, limited research suggests that the sleep environment may at least partially explain differences in sleep along socioeconomic lines. In a sample of adults, sleep environment factors were found to partially mediate links between socioeconomic status and poor self-reported sleep quality in a diverse sample of adults (Mezick et al., 2008).

Another possible mechanism that could link economic disadvantage and sleep is that lower SES children's sleep may be compromised due to worries they have that prevent them from easily falling asleep. Nicassio, Wendlowitz, Fussell & Petras (1985) created the Pre-sleep Arousal Scale that separated arousal into somatic arousal (e.g. heart racing; stomach upset) and cognitive arousal (e.g. being distracted by sounds; worry about falling asleep). Associations between cognitive arousal at bedtime, including worry, and sleep disturbance have been demonstrated in children and adolescents. Alfano, Pina, Zerr, and Villalta (2010) reported that greater cognitive (but not somatic) pre-sleep arousal was associated with shorter sleep duration and more sleep problems reported by parents in an ethnically diverse sample of 7-14 year olds. It is possible that youth who are economically disadvantaged experience greater levels of cognitive arousal as a result of greater exposure to daytime stressors. Economic disadvantage is associated with high levels of family stress, and numerous specific stressors, including exposure to events that are unpredictable and uncontrollable, harsh discipline, and violence at home, school or neighborhood (Miller & Chen, 2013). However, no research has examined whether the higher rates of sleep disturbances in lower SES children may be related to greater pre-sleep worries in that population.

#### *Current Study*

The aim of the current study was to explore novel possible mediators in relations between SES (as indexed by family income-to-needs ratio) and sleep in a community sample of

children with a wide range of SES. Given the importance of examining multiple parameters via objective and subjective methods (Sadeh, 2011), sleep duration and quality (continuity/fragmentation, schedule) were assessed using actigraphy, and subjective sleep/wake problems and daytime sleepiness were assessed with a self-report questionnaire. Pre-sleep worry and the sleep environment were examined with children's self-reports. We predicted that lower SES would be directly related to sleep and that both sleep environment conditions and greater pre-sleep worries would function as mediating variables in the link between lower SES and more subjective and objective sleep problems.

## Method

### Participants

The initial pool of participants consisted of 278 children and their parents who enlisted in a larger study examining biopsychosocial influences on health (Auburn University Sleep Study). The study was approved by the Auburn University Institutional Review Board. The current investigation is based on data collected during the third study wave in 2011-2012. To recruit families, letters inviting participation were distributed to children at semirural public schools in the Southeastern United States. Interested families were asked to call our research laboratory. Exclusion criteria were based on mother reports and included the child having been diagnosed with a sleep disorder or learning disability.

The sample used in the current analyses excluded children without any data on primary study variables and included 271 children (47% girls, 53% boys;  $M$  age = 11.33 years,  $SD$  = 7.74 months, range = 10.00 to 12.67 years). Representative of the community, 62% of children were European American and 38% were African American. Regarding mothers' and fathers' education, 3% and 4% had less than a high school education, 24% and 41% had a high school education, 35% and 31% had some college, 27% and 17% had a college education, and 11% and 7% had a graduate degree, respectively. Based on mothers' reports of pubertal status (1 = prepubertal, 2 = early pubertal, 3 = midpubertal, 4 = late pubertal, 5 = postpubertal; Petersen et

al., 1988), boys were prepubertal ( $M = 1.80$ ,  $SD = .53$ ) and girls were early pubertal on average ( $M = 2.35$ ,  $SD = .61$ ). Further, 79% of children were from two parent homes (e.g., both biological parents, one biological parent and a spouse or partner) and 21% were from single-parent families (mostly single mothers).

## Procedures

Sleep data were collected during the regular school year, excluding holidays. Actigraphs were delivered to the child's home and parents were instructed to place them on the child's non-dominant wrist prior to bedtime for seven consecutive nights. To cross-validate actigraphy data, parents completed child sleep diary logs (Acebo & Carskadon, 2001). Nights during which medication was used were excluded from analyses. Shortly after the actigraph assessment, children and their parents visited the on-campus laboratory to complete questionnaires; 77% of children visited the laboratory on the day following the last night of actigraphy and the rest shortly after. Children's height and weight were measured using the Tanita digital weight scale and wall-mounted stadiometer (Arlington Heights, IL) to compute BMI (scores ranged from 1 [underweight] to 4 [obese]).

## Measures

**Income-to-needs ratio.** Mothers reported on annual family income using the following categories: (a) \$10,000 to \$20,000; (b) \$20,000 to \$35,000; (c) \$35,000 to \$50,000; (d) \$50,000 to \$75,000; (e) more than \$75,000. The mean of family income range and family/household size were used in the calculation of income-to-needs ratio, specifically by dividing family income by the federal poverty threshold for that household/family size (U.S. Department of Commerce; [www.commerce.gov](http://www.commerce.gov)). Families who received an income-to-needs ratio of  $< 1$  were considered to be living in poverty (39% of families in the current sample);  $1 - 2$  = living near the poverty line (28% of families);  $> 2 - 3$  = lower middle class (24% of families); and  $\geq 3$  = middle class standing (9% of families).



**Actigraphy-measured sleep.** Actigraphy was used to objectively measure children's sleep. Participants wore Octagonal Basic Motionloggers (Ambulatory Monitoring, Inc, Ardsley, NY). The actigraphs measured motion in 1-minute epochs using zero crossing mode. The Octagonal Motionlogger Interface with Actme software and the analysis software package (Action W2, 2000 Ambulatory Monitoring Inc.) were used for analyses. Children were considered awake or asleep using the Sadeh scoring algorithm (Sadeh, Acebo, Seifer, Aytur, & Carskadon, 1995; Sadeh, Sharkey, & Carskadon, 1994). Actigraphy has good reliability, especially when used for multiple consecutive nights (Acebo et al., 1999). The actigraph and analysis software package have established validity for the assessment of children's sleep when compared with polysomnography (Sadeh et al., 1994; Sadeh et al., 1995).

The inclusion of multiple sleep parameters is recommended to tap a wide range of sleep-related problems. We assessed: (a) sleep minutes – number of minutes scored as sleep during the sleep period (actigraphy-based sleep onset time to wake time); and (b) night waking duration – average length (in minutes) of each night waking. These parameters are commonly assessed in the child sleep literature (Meltzer et al. 2012). To capture the variability in sleep schedule over the week of actigraphic assessment, variability in sleep onset and variability in wake time were computed, using the mean-centered coefficient of variance statistic (Snedecor & Cochran, 1967), and were mean composited to create (c) variability in sleep schedule.

In total, 38% of children had actigraphy data for all seven nights, 22% had six nights, 20% had five nights, 8% had four nights, 6% had three nights, and 7% had fewer than three nights or no actigraphy data. These rates of valid actigraphy data are considered very good (Acebo et al., 1999). Reasons for missing data included mechanical problems (n = 4 children), forgetting to wear the actigraph (n = 5), having actigraphy measured sleep times that were inconsistent with diary-based bed and wake times (n = 7), and use of medicine known to influence sleep for at least one night (e.g., anti-allergens, cough syrup; n = 19) and exclusion of these nights from analyses. Researchers have recommended that actigraphy assessments

include at least 5 nights (Acebo et al., 1999; Sadeh, 2011). We conducted secondary analyses excluding cases that had fewer than five nights of actigraphy data and findings were similar in nature to study results. Consequently, all cases, regardless of the number of available nights, were retained to enhance power. Further, in support of using all available actigraphy nights, the well-established full information maximum likelihood estimation was used to handle missing data (Acock, 2005). Intraclass correlations indicated good night-to-night stability for sleep minutes ( $\alpha = .79$ ), night waking duration ( $\alpha = .83$ ), variability in sleep onset ( $\alpha = .88$ ) and variability in wake time ( $\alpha = .77$ ) over the week.

**Subjective reports of sleep.** Children reported on their sleep over the past two weeks using the School Sleep Habits Survey (SHS; Wolfson & Carskadon, 1998). The SHS has good reliability and validity (Wolfson et al., 2003). The 10-item Sleep/Wake Problems Scale ( $\alpha = .70$ ) and the 9-item Sleepiness Scale ( $\alpha = .59$ ) were used. The Sleep/Wake Problems Scale assessed the frequency of problems related to several sleep and wake parameters including oversleeping, trouble falling asleep, staying up all night, extreme tiredness at night, and difficulty waking up. The Sleepiness Scale measured the frequency of struggling to stay awake or falling asleep during nine daily activities including while in class, doing homework, attending a performance, watching television, and during a test; one item about driving was excluded. For each scale, higher scores reflect greater sleep-related problems.

**Environmental Conditions.** Children completed a brief instrument similar to the Sleep Environment Inventory (Mezick et al., 2008) to assess factors commonly reported as reasons for disrupted sleep. Seven items assessing physical environmental conditions (see Table 1 for items) were presented and children were asked to rate each item that “keeps them from sleeping well” during the last week. Response choices included 0 = no/not applicable and 1 = yes. Scores on the seven items were summed to create an overall score ( $M = 1.67$ ,  $SD = 1.48$ ; range = 0 to 6); Cronbach’s  $\alpha = .52$ , which is acceptable given the small number of items and the diversity in circumstances that could interrupt sleep.

**Pre-sleep worries.** Five items assessing pre-sleep worries (“...worried about my family,” “...worried about my friends,” “...worried about school work”, “...worried about other kids”, and “...worried about other things”) were used. Children were asked to endorse items that “keep me from sleeping well” in the last week (see Table 1 for items). Similar to modifications used in other published research (e.g. Alfano et al., 2010), items were adapted for youths from the Pre-Sleep Arousal Scale originally developed by Nicassio et al. (1985). Response choices included 0 = no/not applicable and 1 = yes. Items were summed to create a total score ( $M = 1.13$ ,  $SD = 1.50$ ; range = 0 to 5); Cronbach’s alpha = .78.

## Results

### Plan of Analysis

We examined environmental conditions and pre-sleep worries as mediators in the association between income-to-needs ratio and children’s sleep. Five sleep parameters were examined: Actigraphy-derived sleep minutes, night waking duration, and variability in sleep schedule as well as self-reported sleep-wake problems and daytime sleepiness. Actigraphy-derived sleep efficiency (% of minutes scored as sleep between sleep onset and morning wake time) and long wake episodes (number of wake episodes  $\geq 5$  min) were assessed initially but neither yielded significant effects. For power considerations, these sleep parameters were excluded from the final model. Environmental conditions and pre-sleep worries were included simultaneously in the same model (rather than fitting separate models for each). This approach is conservative and allows for the assessment of the unique effects of one mediator (e.g., environmental conditions) while controlling for the other (e.g., pre-sleep worries) and vice versa. Similarly, all five sleep variables were examined simultaneously to decipher “unique” effects.

We examined both environmental conditions and pre-sleep worries as mediators of relations. If no mediation effects emerged, we considered environmental conditions and pre-sleep worries as intervening variables in the link between income-to-needs ratio and sleep. In both a mediation model and intervening variable model, the independent variable shares a

significant relation with the mediator or intervening variable, which in turn is significantly related with the outcome variable (Mackinnon, Lockwood, Hoffman, West, & Sheets, 2002). Thus, mediating and intervening variables bridge the association between the independent and dependent variable and play a role in explaining why two variables are related. In a mediation model, the relation between the independent and dependent variable is significant prior to the inclusion of the mediating variable (Baron & Kenny, 1986) whereas in an intervening model, no such significant relation exists. Examination of intervening processes are common in the literature and a significant effect suggests that the relation between two variables might be contingent on an intervening variable (Mackinnon, Lockwood, Hoffman, West, & Sheets, 2002; Shrout & Bolger, 2002). Further, the study utilized a cross-sectional design and thus, reference to prediction of change in the mediator or dependent variable is used in the statistical sense rather than the prediction of change that might be inferred with a multi-wave design.

Monte Carlo simulation was used to assess the indirect effects (Preacher & Selig, 2012). This method produces confidence intervals of the hypothesized indirect effects by generating a large number of estimates (20,000 in this study) of an indirect effect by resampling from the distributions of each direct effect. Confidence intervals for testing indirect effects were generated using Selig and Preacher's (2008) interactive tool; an indirect effect was demonstrated when the confidence interval did not contain zero. To minimize outlier effects among primary study variables, data points that surpassed 3 *SDs* were recoded as the highest observed value below 3 *SDs* (Cousineau & Chartier, 2010). Five values were recoded for sleep minutes, four values for night waking duration, three values for variability in sleep schedule, one value for sleep/wake problems, and five values for daytime sleepiness.

Child gender, ethnicity, medication use (e.g., acetaminophen), and BMI were included as covariates given their known associations with several primary study variables and their significant impact on model fit. Pubertal status, asthma (12% of children had asthma based on parents' reports), and chronic illness (6% of children had a chronic illness; e.g., sickle cell,

eczema, ulcers) were initially considered as covariates but none yielded a significant influence on model fit and thus were excluded. The control variables were allowed to correlate with each other as well as with income-to-needs ratio and were allowed to predict environmental conditions, pre-sleep worries, and the sleep parameters.

Analyses were conducted using Amos 21 (Arbuckle, 2012). Full information maximum likelihood estimation was used to handle missing data (Acock, 2005). The residual variances among environmental conditions and pre-sleep worries were allowed to correlate as were the residual variances among each of the sleep parameters. Non-significant covariances among exogenous variables were omitted to increase degrees of freedom (versus fully saturating the model). Acceptable model fit was based on satisfying at least two of the three following criteria:  $\chi^2/df < 3$ , CFI  $> .90$ , and RMSEA  $\leq .08$  (Browne & Cudeck, 1993). In initial analyses, we examined exacerbation of risk by assessing whether child gender and ethnicity served as moderators in the mediation model (moderated mediation); no significant interaction effects were detected and thus these variables were not considered further.

### **Preliminary Analyses**

Descriptive statistics are presented in Table 2. Based on actigraphy, children slept on average 7 h 16 min per night and the average night waking duration was nearly 6 min. Actigraphy-based information indicated that the average sleep onset time was 10:06pm ( $SD = 47$  min) and the average morning wake time was 6:16am ( $SD = 42$  min). A relatively wide range of variability in sleep schedules and other primary study variables was observed. Bivariate correlations among primary study variables are also presented in Table 2.

### **Examination of direct effects between income-to-needs ratio and children's sleep**

Prior to mediation analyses, a model was first fit to examine the direct associations between income-to-needs ratio and sleep (the direct effects model is not depicted in a figure). After controlling for the covariates, lower income-to-needs ratio was moderately related to fewer

sleep minutes ( $B = 6.35, \beta = .12, p = .08$ ) as well as greater sleep/wake problems ( $B = -.84, \beta = -.16, p = .01$ ) and increased sleepiness ( $B = -.42, \beta = -.15, p = .01$ ).

### **Income-to-needs ratio and children's sleep: Environmental conditions and pre-sleep worries as mechanisms of risk**

Next, environmental conditions and pre-sleep worries were added to the model for their assessment as mediators and intervening processes among relations between income-to-needs ratio and children's sleep (Figure 1). The model fit the data well,  $\chi^2(4) = 4.85$  *ns*;  $\chi^2/df = .82$ ; CFI = .99; RMSEA = .03*ns*, 95% CI [.00 to .10]. Overall, the model explained 12% of the variance in sleep minutes, 9% in night waking duration, 5% in variability in sleep schedule, 29% in sleep/wake problems, and 21% in sleepiness.

Many control variables were related to primary study variables (not shown in Figure for clarity). Male gender was related to fewer sleep minutes ( $B = -14.41, \beta = -.13, p = .03$ ) and less sleepiness to a moderate extent ( $B = -.70, \beta = -.11, p = .06$ ). African American ethnicity was related to more pre-sleep worries ( $B = .55, \beta = .18, p = .004$ ), fewer sleep minutes ( $B = -21.35, \beta = -.19, p = .002$ ), longer night waking duration ( $B = .53, \beta = .13, p = .04$ ), and greater sleep/wake problems ( $B = -.69, \beta = -.11, p = .06$ ). Medication use was related to more sleep/wake problems ( $B = 2.00, \beta = .13, p = .02$ ). Higher BMI was related to fewer sleep minutes ( $B = -2.32, \beta = -.24, p < .001$ ) as well as to longer night waking duration ( $B = .06, \beta = .17, p = .006$ ) and increased sleep/wake problems ( $B = .12, \beta = .12, p = .03$ ).

As shown in Figure 1, and to a moderate extent, lower income-to-needs ratio was directly related to fewer sleep minutes ( $B = 5.89, \beta = .12, p = .06$ ) as well as to greater disruptive environmental conditions ( $B = -.19, \beta = -.16, p = .04$ ) and pre-sleep worries ( $B = -.20, \beta = -.16, p = .04$ ; Figure 1). Greater environmental conditions that disrupt sleep were associated with more variability in sleep schedule ( $B = .01, \beta = .16, p = .03$ ) and greater sleep/wake problems ( $B = .91, \beta = .25, p < .001$ ) and sleepiness ( $B = .47, \beta = .22, p < .001$ ). Further, heightened level of pre-sleep worries was related to longer night waking duration ( $B = .24, \beta =$

.18,  $p = .03$ ), greater sleep/wake problems ( $B = .96$ ,  $\beta = .27$ ,  $p = .001$ ), and more sleepiness ( $B = .55$ ,  $\beta = .26$ ,  $p < .001$ ).

**Environmental conditions.** The mediating role of environmental conditions in relations between income-to-needs ratio and sleep was examined. As previously reported, lower income-to-needs ratio was related to greater disruptive environmental conditions, which in turn were associated with more variability in sleep schedule (Figure 1). Because income-to-needs ratio was not directly related to variability in sleep schedule, environmental conditions served as an *intervening process* in these relations; the indirect effect was significant (95% CI [-.01 to -.001]). Further, because income-to-needs ratio was directly related to sleep/wake problems and sleepiness as well as environmental conditions, and environmental conditions were related to sleep/wake problems and sleepiness, the mediating role of environmental conditions was assessed. While examining one potential mediator, we temporarily constrained the pathway between the other potential mediator and the sleep outcome variable of interest. Along this line, the pathways from pre-sleep worries to sleep/wake problems and sleepiness were constrained. Analyses indicated that the level of significance between income-to-needs ratio and sleep/wake problems was reduced ( $p$ -value changed from .01 to .04), thus suggesting that disruptive environmental conditions partially *mediated* relations between income-to-needs ratio and sleep/wake problems; the indirect effect was significant (95% CI [-.58 to -.04]). Similarly, the  $p$ -value of the direct effect between income-to-needs ratio and sleepiness became non-significant ( $p$ -value changed from .01 to .14), indicating that environmental conditions fully *mediated* relations between income-to-needs ratio and sleepiness (95% CI [-.36 to -.03]).

**Pre-sleep worries.** The mediating role of pre-sleep worries in relations between income-to-needs ratio and children's sleep was assessed. As previously reported, lower income-to-needs ratio was related to more pre-sleep worries, which in turn was related to greater night waking duration (Figure 1). Because income-to-needs ratio was not directly related to night waking duration, pre-sleep worries served as an *intervening variable* in these relations (95% CI

[-.15 to -.002]). Further, we assessed whether pre-sleep worries mediated relations between income-to-needs ratio and sleep/wake problems and sleepiness. The paths from environmental conditions to sleep/wake problems and sleepiness were first constrained to remove the effect of environmental conditions. The level of significance between income-to-needs ratio and sleep/wake problems was reduced ( $p$ -value changed from .01 to .05), thereby indicating that pre-sleep worries partially *mediated* relations between income-to-needs ratio and sleep/wake problems (95% CI [-.54 to -.08]). Lastly, the  $p$ -value of the direct effect between income-to-needs ratio and sleepiness became non-significant ( $p$ -value changed from .01 to .17), indicating that pre-sleep worries fully *mediated* relations between income-to-needs ratio and sleepiness (95% CI [-.31 to -.04]).

### Discussion

This study adds to a scant literature by exploring novel pathways linking lower SES to actigraphically-derived and self-reported sleep problems during late childhood. Results showed a few direct associations between lower SES and sleep problems. Further, central to study hypotheses, models testing indirect effects indicated that increased exposure to disruptive sleep conditions and greater pre-sleep worries serve as either mediators or intervening variables explaining some of the associations between SES and sleep. Across sleep parameters, the model explained 5% to 29% of variance, suggesting that both sleep environment and psychological factors contribute to socioeconomic disparities in sleep for children in important ways.

A growing number of studies have demonstrated that lower SES living conditions are not conducive for children's sleep (El-Sheikh et al., 2013; Fredriksen et al., 2004; Marco et al., 2012), however critical questions remain regarding why such relations exist (Knutson, 2013). Toward addressing this gap, our findings pertaining to environmental conditions indicate that they serve as mediators of direct significant associations between income-to-needs ratio and children's sleep/wake problems and daytime sleepiness. Specifically, disruptive environmental



living conditions partially mediated relations between income-to-needs ratio and subjective sleep/wake problems and fully mediated relations between income-to-needs ratio and daytime sleepiness. In addition to mediation effects, an intervening process was observed in which environmental conditions linked SES and variability in sleep schedule. Intervening processes are of importance and help identify variables that could potentially bridge relations between SES and sleep.

Several mediation and intervening effects involving pre-sleep worries were observed. Specifically, pre-sleep worries partially mediated relations between income-to-needs ratio and subjective sleep/wake problems and fully mediated relations between this index of SES and daytime sleepiness. Further, pre-sleep worries served as an intervening variable linking SES with night waking duration. The simultaneous inclusion of both environmental conditions and pre-sleep worries in the same model helps more closely ascertain the unique effect of each mediating/intervening variable and lends confidence in the findings. Overall, our study advances the child literature in important ways and is one the first to demonstrate that environmental concerns and pre-sleep worries explain, at least partially, why lower SES relates to children's sleep.

Inconsistent with expectations, lower SES was not directly related to actigraphy measured night waking duration and variability in sleep schedule. It is unclear why such relations were not detected. The conservative nature of assessments including controlling for influential covariates and reducing mono-reporter bias (e.g., parent reports of SES and actigraphy measured sleep) might have contributed to the null effects. However, evidence of intervening processes was found, such that lower SES was related to environmental conditions, which in turn was related to greater variability in sleep schedule. In addition, lower SES was related to longer night waking duration through their shared relations with pre-sleep worries. The intervening rather than mediation effect suggests that the inclusion of environmental conditions and pre-sleep worries are required to observe the indirect effect between lower SES and either

night waking duration and variability in sleep schedule (MacKinnon et al., 2002; MacKinnon, 2000). Further, evidence of a direct effect between lower SES and sleep is not a required criteria for our conceptual model, which proposes that lower SES ultimately undermines children's sleep by creating living conditions that are not conducive to sleep and setting in motion greater pre-sleep worries.

It is notable that among all of the individual items on both pre-sleep and environmental conditions measures, only one item (worry about family) was more likely to be endorsed by lower-SES children. Yet, when considered as summed scale scores both greater sleep environment concerns and pre-sleep worry were associated with lower SES. This suggests a complex challenge for prevention and intervention efforts in that there is likely no *single* target for eliminating disparities in sleep. Still, improvements to the physical sleep environment may help children attain better sleep, and relatively inexpensive devices (e.g., fans; dehumidifiers; white noise generators) should be empirically evaluated for efficacy in ameliorating some sleep problems. Helping children deal with worries that disrupt their sleep has already been incorporated into some sleep intervention studies (e.g. Britton et al. 2010) and may be a particularly potent intervention for children from lower SES backgrounds.

The diverse sample, which included a wide range of family SES is scarce in the literature, and multi-method sleep assessments were important strengths of the present study. However, there are some limitations worth noting that highlight the need for further research aimed at understanding socioeconomic disparities in sleep. We chose to focus on income-to-needs ratio as it may best reflect the material resources of a family, yet other aspects of SES including parental education may relate to children's sleep through similar or different pathways. Although our measures of environmental concerns and pre-sleep worries were based on prior scales, it is possible that there are important additional concerns or worries that were not included in these measures. Further, because our scales were sum scores they reflect the *number* of stressors endorsed by children, but not the severity of those stressors. There may be

important qualitative and quantitative differences in the concerns or worries that children have based on SES. For example, the “noise outside” that affects sleep may also be threatening and pre-sleep worries may vary greatly in terms of their intensity or potential consequences. Further, our assessment of pubertal status and the exclusion of clinical sleep disorders relied on maternal report and could have been improved through child reports or clinical assessment. Also, our study has not examined coping mechanisms that children employ to deal with these bedtime stressors or catastrophizing cognitions, which may represent an additional vulnerability factor for children from low-SES homes.

The importance of research exploring the processes that underlie links between sleep behaviors and economic disadvantage in youth is becoming more evident as a growing body of literature shows that sleep during childhood and adolescence is not only important concurrently (Shochat, Cohen-Zion, & Tzischinsky, 2014), but also predictive of health outcomes into adulthood, above and beyond the effects of adult sleep (Landhuis, Poulton, Welch, & Hancox, 2008). The findings of this study represent an early step in explaining sleep disparities in youth and serve as a jumping off point for future studies in this important area. It is likely that through a more fine-grained, nuanced understanding of the social, psychological, and physical context within which sleep occurs, effective prevention programs can be developed.

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Percent endorsement	<i>r</i> with income-to-needs ratio	<i>r</i> with sleep minutes <sup>a</sup>	<i>r</i> with night waking duration <sup>a</sup>	<i>r</i> with variability in sleep schedule <sup>a</sup>	<i>r</i> with sleep/wake problems <sup>b</sup>	<i>r</i> with sleepiness <sup>b</sup>
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Figure 1. Path model of environmental conditions and pre-sleep worries as mediators of relations between income-to-needs ratio and sleep. Model fit:  $\chi^2(4) = 4.85$  ns;  $\chi^2/df = .82$ ; CFI = .99; RMSEA = .03ns, 95% CI [.00 to .10]. Residual variances among environmental conditions and pre-sleep worries were allowed to correlate as were the residual variances among the sleep parameters. Statistically significant lines are solid and non-significant lines are dotted. Covariates were child gender, ethnicity, medication use, and body mass index. <sup>a</sup> $p < .10$ ; <sup>\*</sup> $p < .05$ ; <sup>\*\*</sup> $p < .01$ ; <sup>\*\*\*</sup> $p < .001$ .

Table 1

*Correlations between Environmental Conditions and Pre-Sleep Worries Items and Income-to-Needs Ratio and the Sleep Parameters*

Environmental Conditions							
Noise outside	27.2%	-.08	-.12 <sup>t</sup>	.16*	.05	.25**	.17**
Noise inside	32.5%	-.07	.01	.02	.07	.17**	.20**
Someone snoring	19.6%	-.11 <sup>t</sup>	-.01	-.05	.02	.24**	.18**
Uncomfortable bed	18.9%	-.01	-.05	.03	.05	.27**	.25**
Temperature of room	36.9%	-.04	-.09	.04	.15*	.22**	.13*
TV, radio, or computer	24.9%	-.10	.01	.10	.02	.23**	.19**
Too much light	9.2%	-.04	-.03	.03	-.06	.05	.14*
Pre-sleep Worries							
About schoolwork	19.7%	-.01	-.08	.07	.14*	.19**	.17**
About family	29.7%	-.18**	-.16*	.20**	-.04	.37**	.36**
About friends	21.3%	-.10	-.13*	.19**	-.03	.24**	.24**
About other kids	12.8%	-.10	-.12 <sup>t</sup>	.18**	-.06	.27**	.27**
About other things	30.4%	-.03	-.04	.01	-.05	.40**	.32**

<sup>a</sup> This measure is actigraphy derived.

<sup>b</sup> This is a child-reported sleep measure.

<sup>t</sup>  $p < .10$ ; \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

Table 2

*Descriptive Statistics and Correlations among Study Variables*

	1.	2.	3.	4.	5.	6.	7.	8.	<i>M</i>	<i>SD</i>
1. Income-to-needs ratio	-								1.49	.99
2. Environmental conditions	-.14*	-							1.69	1.50
3. Pre-sleep worries	-.14*	.50***	-						1.14	1.50
4. Sleep minutes <sup>a</sup>	.16**	-.07	-.14 <sup>t</sup>	-					436 min	55 min
5. Night waking duration <sup>a</sup>	-.08	.09	.16**	.63***	-				5 min and 51 sec	3 min and 25 sec
6. Variability in sleep schedule <sup>a</sup>	.10	.11 <sup>t</sup>	-.01	-.03	.07	-			.08	.05
7. Sleep/wake problems <sup>b</sup>	-	.40***	.41***	-	.19**	.05	-		17.39	5.38
8. Sleepiness <sup>b</sup>	-.14*	.36***	.38***	-.04	.08	-	.39***	-	12.29	3.22
						.06				

Note. For sleep minutes, 436 min translates into 7 h and 16 min

<sup>a</sup> This measure is actigraphy derived.

<sup>b</sup> This is a child-reported sleep measure.

<sup>t</sup> $p < .10$ ; \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

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